

## **Bone-Adaptive Surface Structure**

### **CROSS REFERENCE TO RELATED APPLICATIONS**

This application claims priority under 35 U.S.C. §119 to EP 02090379.5  
5 filed November 15, 2002, which claims priority to DE 20208975 U filed June 10, 2002.

### **TECHNICAL FIELD OF THE INVENTION**

The invention concerns bone-adaptive surface structures for lateral jaw  
10 implants; that is, for implants which are inserted into the jaw from the side, and which are also known as “disk implants.”

### **DESCRIPTION OF THE RELATED ART**

Various industrially produced implants have been used for decades in  
15 dental implantology. These include cylinder implants, screw implants, leaf implants, and disk implants. Individually produced subperiosteal implants also play a part.

These implants developed from a kind of box shape. They generally have a disk-shaped implant base. U.S. 3,925,892 (Juillet) describes an implant with a  
20 rectangular base and a post screwed onto it. Then the crown or the prosthesis is fastened to the post. According to U.S. 4,722,687 (Scortecci) a congruent osteotomy instrument was developed later, as well as an osteotomy tool which simultaneously served as its own implant, and so was left in the bone (U.S. 4,815,974). Later, U.S. 4,344,757 described other possible forms, as did U.S.  
25 4,964,801 (Kawahara).

All the developments mentioned above had in common the fact that they essentially improved the geometry, or the external shape, of the implants. That contributed to a broader range of possible uses, lower fracturability, and better retention.

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## SUMMARY OF THE INVENTION

The strongest possible hold in the jawbone is an essential objective of any implant. Aside from the variously shaped bases intended to help the implant grow into the jaw bone and improve its firm seating, surface structures intended to improve the holding of the implant have been discussed quite recently. These involve combinations of air abrasion („sandblasting“) processes with etching processes. Etching has the additional objective of removing residue from mechanical processing and abrading from the surface of the implant. These processes treat the surface at the microscopic level.

The invention is based on the objective of accelerating the healing process of the implant into the jawbone after its insertion, and of critically improving the anti-rotational retention of the implant.

The objective is attained according to the invention by lateral jaw implants according to the features of Claim 1. Advantageous further developments of the invention appear in Subclaims 2 to 20.

It has been found that significant improvements of the retention of the implant can be achieved by lateral implants, by means of macromechanically acting surface structures and even macromechanical surface forming, independently of the geometry of the implant body. At first glance, it appears impossible to apply macromechanical surface structures to lateral implants. It was determined that the implant bed prepared in the jawbone from laterally must be very thin, so that the blood supply is not too seriously impaired and so that primary bone healing is possible. Surprisingly, it was later found that having a surface structure in the form of grooves with profiles which are corrugated, pointed, or sawtooth-like, and which are arranged in parallel, concentric with the thread carrier, or in the form of a spiral form on the upper and/or the lower surface of the base, and which can at least in part extend onto the bar of the implant, can be inserted relatively easily if the height of the osteotomy slot does not exceed the core height  $h_2$  of the surface structure. After insertion of the implant, the surface structures force themselves into the jawbone. This is promoted by the force of

chewing, because the surface structures are perpendicular to the masticatory force. That differs from the situation with crestal (screw) implants, in which the threads, etc., lie transversally to the direction of chewing.

It has been determined from histological sections that small particles of  
5 bone are scraped off the jawbone during the insertion into the depressions of the surface structures. That avoids formation of voids, and the bone particles that are scraped off substantially accelerate the healing process.

Histologic examinations have also shown that the jawbones optimally tolerate contact of the basal structures of implants having a macromechanical  
10 surface structure. If the depth F of the macromechanical surface structure is from 0.05 to 2  $\mu\text{m}$ , direct bone contact with the implant occurs (osseointegration). It is therefore unnecessary to apply an additional microstructure, such as, for example, titanium coatings applied by plasma spraying. Dispensing with such measures not only reduces cost, but also prevents the layers applied from producing  
15 supplemental microstructure separating from the surface during insertion of the implant, or later, thus causing inflammation and symptoms resembling polymetallosis.

According to an advantageous further development of the subject of the invention, the surface structures are worked into the base of the implant only in  
20 selected annular regions. Such implants present a situation in which only the annular regions with the enlarged surfaces are osseointegrated, while all the other regions experience only moderate osseointegration or are overgrown with connective tissue. This implant configuration is particularly advantageous for use in the vicinity of the maxillary sinuses. In this case the surface of the part of the  
25 implant in the vicinity of the maxillary sinus is smooth, resulting in very good self-cleaning, while the cortically anchored regions, i.e., the annular regions, have enlarged surfaces and so are integrated better. In this embodiment, supplemental microstructure of the surfaces by etching, air-abrading, etc., is again not necessarily required with this embodiment of lateral implants.

The advantageous effects noted above also appear if the surface structure consists of bowl-like depressions.

According to a further feature of the invention, the surface structures can be formed by variously shaped depressions and milled-out regions worked into the marginal zones of the base. In this variant embodiment, the geometry of the depressions, which differ from each other, should advantageously be selected such that the forms of the depressions in contact produce a configuration with reentrant angles. Furthermore, the substrate can in turn be formed so that it ends in the peripheral region of the base with a core height of  $h_2$ .

Aside from the advantages noted which are also attainable with this solution, the peripheral depressions in the base substantially improve the ingrowth because the jaw bones tend to close, reaching and filling out the depressions with smaller configurations sooner than those with somewhat larger configurations. In this way, a high initial strength can be attained considerably sooner.

If lateral implants of the type according to the invention also have elastic properties, then the threaded parts sink into the spongy bones under stress. That results in a tension directed centrally on the threaded parts. In this situation, the surfaces of the previously known lateral implants can tear out of the bone combination. However, due to the surface structures according to the invention, it is possible to maintain the combination with the bone even under large stresses. Thus individual implants can be more heavily loaded, with the result that fewer implants per jaw are needed to reproduce the ability to chew. In this way, even severely atrophied jaws can be cared for without bone grafting.

With proper selection of microdimensions and macrodimensions, it is possible to provide an implant which fits biomechanically into the bone but is still easily insertable, and which has a surface structure that offers the implant optimal macromechanical hold in the jawbone. Then the vertically acting masticatory forces are absorbed in an astonishing manner by the likewise vertical structures

such as, for example, the grooves made in the surface of the implant base and/or bar.

It is also possible to elevate the surface structure by sintering one or more layers of balls of titanium or a titanium alloy having a diameter of 120 to 220  $\mu\text{m}$  onto the desired surfaces of the implant. This likewise provides higher surface roughness without additional micromechanical measures such as those described above.

From extensive series of histological examinations and cracking tests, it has been found that the best results for adhesion are attained with the dimensions shown below for the bases and surface structures:

- Implant diameter D / implant width: 8 – 15 mm
- Height h3 of the implant base where it joints the thread carrier: 0.7 – 1.2 mm
- Distance E between the peaks of the surface structure: 0.2 – 0.7 mm
- Width G of the ring for the implant base: 1.0 – 2.4 mm
- Core height h2: 0.6 – 0.9 mm
- Depth F of the surface structure: 0.05 – 0.25 mm.

Lathe-turning or milling processes, or a combination of those two processes, are particularly suitable for producing implants according to the invention. The well-known air-abrading or etching processes are used advantageously for final working.

The surface structures according to the invention can be produced in a particularly elegant manner using ablative laser processes. This kind of production also favors production of bowl-like surface structures.

## BRIEF DESCRIPTION OF THE DRAWINGS

Reference is now made more particularly to the drawings which illustrate the best presently known mode of carrying out the invention and wherein similar reference characters indicate the same parts throughout the views:

5        Figure 1a is Section L – L of Figure 1b.

Figure 1b is a plan view of a bone-adaptive lateral jaw implant with surface structures according to the invention, with a rectangular base.

Figure 1c is a plan view of a jaw implant according to the invention with a spiral design and arrangement of the surface structures. This design can be held  
10        extraordinarily well (strongly) in the bone.

Figure 2 is a lateral jaw implant according to the invention with a round base.

Figure 3 is the section M – M through the bar of the implant shown in Figure 2 with a further advantageous arrangement of a surface structure according  
15        to the invention.

Figure 4 is a sectional view of an annular section of the base with a surface structure ending in points.

Figure 5 is an annular section of a base with a corrugated surface structure, with a pointed surface structure also provided in the inner wall area of the base.

20        Figure 6 is a view of a base with a bowl-like surface structure.

Figure 7 is an annular section of a base with a sawtooth-like surface structure.

Figure 8 is a front view of the implant shown in Figure 9.

Figure 9 is a lateral implant having depressions worked into its base, in  
25        agreement with the present invention.

Figure 10 is the left side view of the implant shown in Figure 9.

## DETAILED DESCRIPTION

As can be seen in Figure 1, 1 indicates the screw thread that connects with the prosthesis. That thread can be made as an internal or external thread. Numeral 2 indicates the annular body of the implant. Numeral 3 is the thread holder which connects the annular body with the threads. The bar that connects the thread holder 3 to the base 2 is designated as 4. It has been determined that implants of this type transfer the masticatory force essentially into the peripheral annular section of the base 2, indicated here by 5, which is anchored in the cortical jaw bone. Numbers 6a, 6b and 6c indicate the surface structure according to the invention that extends beyond the level of the base 2. G indicates the width of the base 2 or the diameter of the base 8.

As shown in Figure 1b, the surface structures according to the invention are formed by grooves 6 which can run parallel with each other, as shown at the left of the thread holder 3, or concentrically, as shown at the right of the thread holder 3.

In the embodiment shown in Figure 1c, the surface structures 6, which can have a profile such as shown in Figures 4, 5 and 7, have a spiral shape and extend essentially over the entire upper and/or lower surface of the base 2, with the center of the spiral placed in the region where the screw holder 3 connects to the foot 4.

Figure 2 shows another variant of the basic form of the implant, a round implant in this case. The corrugated or pointed surface structures 6a, 6c, which are formed by the grooves 6, are placed as far as the thread holder 3 in the upper part B of Figure 2, while in the lower part C of Figure 2 they extend only to the junction of bar 4 with the base 8. The latter of the two embodiments has the advantage that this design increases the breaking strength of the base 2 in the vicinity of the bar 4. D indicates the implant diameter. There is a single diameter for the round implants, while there can be numerous diameters for longitudinal implants or for implant with multiple force-transferring bases.

In the presentation of Figure 3, the surface structures continue up to the screw holder 3 at the left part (B) of the figure, while in the right part (C) they

terminate at the left. Therefore, the central height  $h_3$  of the base 8 terminates at a core height  $h_2$  of the ring of the base 8, so that the surface structures according to the invention either maintain the central height  $h_3$  or, as shown in the right part, C, diminish outwardly and are less high in the peripheral region of the base 2, resulting in a core height  $h_2$ . It is entirely possible, though, for the surface structure in the peripheral region to have a height which exceeds the central height  $H_3$  of the base 8, 2 and the surface structure terminates in the vicinity of the junction of the thread holder 3 and foot 4 at the implant height  $h_3$  with continuous decrease of the depth of the selected profile shape. R1 indicates the radius of the transition from the thread holder 3 to the bar 4. K indicates the direction of the principal masticatory force. However, forces that occur with laterotrusion motions during the act of chewing also act at an angle, even perpendicularly, to the main masticatory force.

Figure 4 shows a bone-adaptive surface structure with a corrugated profile which terminates in points, with which the substrate or the wave valleys 7a have essentially a round concave shape.

Figure 5 shows another optimized variant for the shaping of the surface structure 6b which is also inserted in the vertical sidewall surface of the force-transferring base, 2, 8. The shaping of such structures on the outer side of the implant in particular is being proven clinically. A' indicates the direction opposite to the insertion path. E indicates the distance between corrugations or points of the surface structure. According to the results of the investigations on which this application is based, it is optimally 0.2 – 0.7 mm.

Figure 6 shows a section of the base in which the surface structure according to the invention is formed by individual elevations with bowl-like depressions between them made by milling or by lasers. The depth of these depressions is preferably 0.05 – 0.25 mm, as was determined, surprisingly, by investigations. Greater depths retard osseointegration, while lesser depths do not give good results for bone adherence of the implant.



Surface structures with edges 10 perpendicular or approximately perpendicular to the direction of insertion and slowly diminishing concave sides 11 also give particularly good adhesion values. These sawtooth-like structures can be produced either just over the annular region of the base or over the entire 5 implant. However, for reasons of production technology, it can be difficult to provide truly perpendicular edges because the initially vertical edges formed by lathe-turning or machining can be flattened by ablative abrading. In production, the result is that the angles are between 80 and 90 degrees, but they all give good clinical results.

10 In the embodiment shown in Figures 8 to 10, depressions 12, 13 and 14, 15 are made in the base 8 of the lateral implant. They have a different configuration, in that the geometries that deviate from each other are selected so that there is a reentrant angle between the forms of the adjacent depressions 12, 13 and 14, 15. Following insertion of the implant into the ground osteotomy slot, the jaw bone, 15 which has the tendency to draw together, will reach into the lesser depressions 12 and 14 more quickly than into the depressions 13, 15 with the greater shaping. In this way, high initial strength is attained relatively rapidly, with the bone particles scraped off during the insertion and collected in the depressions 13, 15 promoting bone formation and healing of the implant. The depression 17, directed toward 20 the underside of the implant and preferably placed obliquely, makes it easier to insert the implant into the osteotomy slot.